

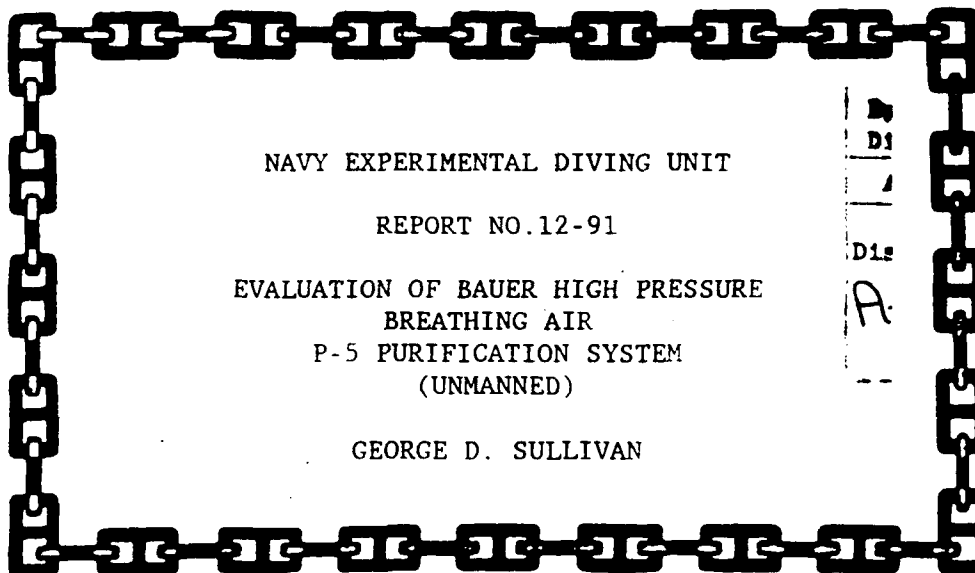
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NAVY EXPERIMENTAL DIVING UNIT

REPORT NO. 12-91

EVALUATION OF BAUER HIGH PRESSURE  
BREATHING AIR  
P-5 PURIFICATION SYSTEM  
(UNMANNED)

GEORGE D. SULLIVAN

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NAVY EXPERIMENTAL DIVING UNIT



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DEPARTMENT OF THE NAVY  
NAVY EXPERIMENTAL DIVING UNIT  
PANAMA CITY, FLORIDA 32407-5001

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NAVSEA TASK -91-002

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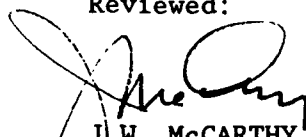
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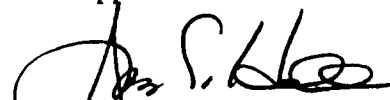
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19. ABSTRACT (Continue on reverse if necessary and identify by block number) In response to NAVSEA tasking, Navy Experimental Diving Unit (NEDU) tested the BAUER P-5 high pressure, breathing air purification system from 24 July 1991 to 12 August 1991. The purpose of this test was to determine if the P-5 air purification system functioned as specified and was suitable for use by the U.S. Navy. Additionally, if the system passed the test criteria a recommendation would be made to add it to the Approved for Navy Use (ANU) list.  The BAUER P-5 air purification system met the manufacturer's specifications for quantity of air processed with a quality which met the U.S. Navy purity standards. The design and engineering were determined to be adequate. The BAUER P-5 purification system is considered suitable for use with U.S. Navy divers high pressure breathing air compressors.				
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## I. INTRODUCTION

In response to NAVSEA tasking<sup>1</sup>, the BAUER P-5 high pressure breathing air purification system, Figure 1, was tested<sup>2</sup> by NEDU. The test determined if the purification system would provide suitable breathing air and a service life satisfying U.S. Navy requirements for use with divers air supply compressors. Charge rates were taken to calculate total cubic feet of air processed each day.

## II. EQUIPMENT DESCRIPTION

### A. PURIFICATION SYSTEM

The purification system consists of three cylinders. The upstream cylinder contains a molecular sieve and is a coalescing type separator that removes oil and water vapors suspended in the compressed air. The molecular sieve is made to adsorb oil and water vapors. The second cylinder uses cartridge No. 058825 and is a dryer only. The third cylinder contains a No. 058827 cartridge with hopcalite and activated charcoal and is a dryer and purifier. The hopcalite converts carbon monoxide (CO) to carbon dioxide (CO<sub>2</sub>). The activated charcoal removes odors, taste, and fluorocarbons.

A pressure maintaining/non-return valve is provided down stream from the purification system to ensure that a 2000 pounds per square inch gauge (psig) pressure build up occurs in the cylinders during compressor start up. This provides for optimum filtering, moisture separation and prevents compressed air return from the charged air storage flasks to the compressor during unit shut down.

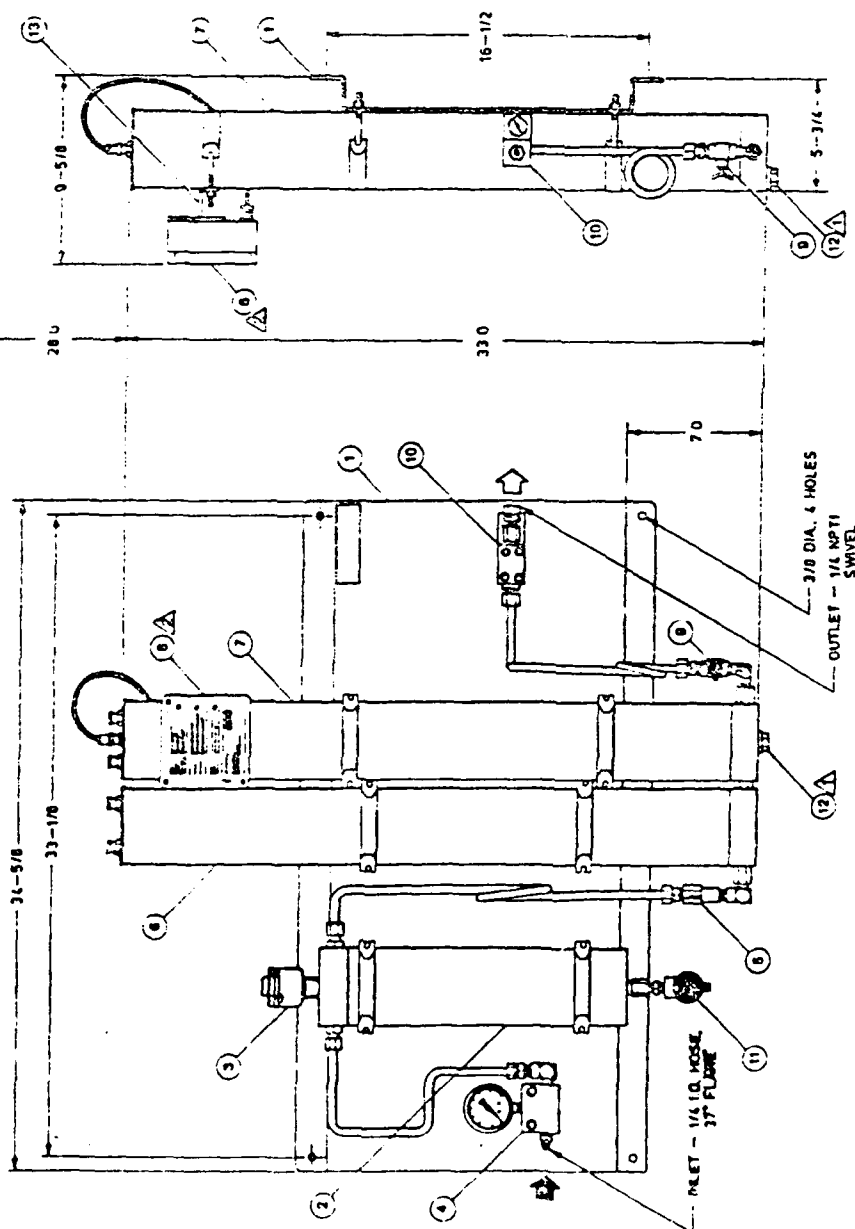
A manual condensate drain valve is located on the bottom of the separator cylinder, a relief valve is mounted on top. A system bleed off valve is located between the last cylinder and the pressure maintaining valve.

The P-5 purification system is rated to process 90,000 cubic feet of free air at 70°F. Maximum air flow is 40 cubic feet per minute (cfm) of free air at 5000 psig. The manufacturer provides a correction factor to assist in determining the service life of the cartridge when operated at other than 70°F. Figure 2 is a line graph for determining the correction factors for a given temperature.

### B. COMPRESSOR

The compressor used for this test was a Bauer K-20 four-cylinder, four-stage, reciprocating, air-cooled unit. The compressor is rated to deliver 20 cfm of free air compressed to 5000 psig.

MINIMUM CLEARANCE REQUIRED  
FOR CHANGING CARTRIDGES



NOTES

△ THIS CHAMBER MUST BE CONNECTED  
TO A POSITIVE EARTH GROUND  
USING THE SCREW PROVIDED.

△ OPTIONAL

ITEM NO.	DESCRIPTION
13	MOUNTING BRACKET
12	GROUND SCREW
11	CONDENSATE DRAIN VALVE
10	PRESS. MAINT. VALVE
9	VENTING VALVE
8	SECURUS
7	PURIFIER
6	DRYER
5	NON-RETURN VALVE
4	INTAKE MANIFOLD w/GAUGE
3	FINAL SAFETY VALVE
2	SEPARATOR
1	MOUNTING PANEL
OUTLINE DIMENSIONS	
1 1/4" x 1 1/2" x 1 1/2"	HPV
1 1/4" x 1 1/2" x 1 1/2"	STANDARD
PURIFICATION PANEL, PS/SECURUS	
RAUER COMPRESSORS, INC. ASY-60	

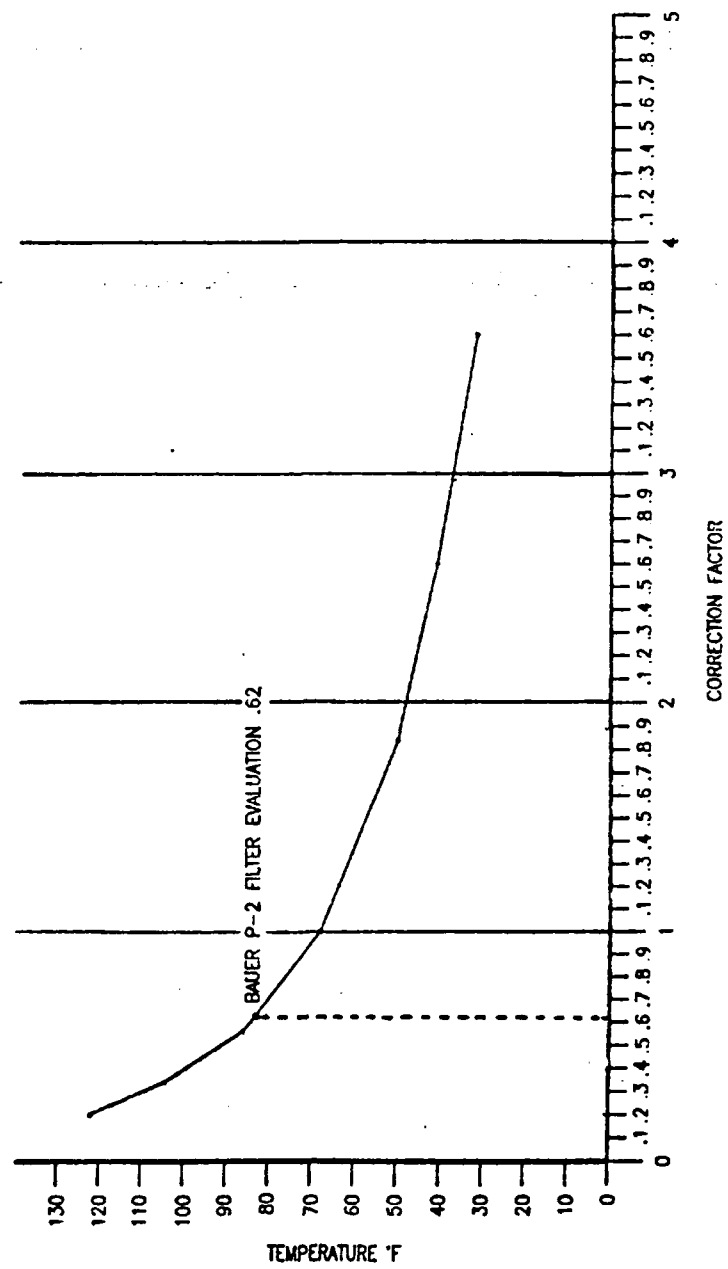


FIG. 2



### III. TEST PROCEDURE

The Bauer Purification System's instruction pamphlet<sup>3</sup> was used to conduct an initial inspection of the equipment to ensure receipt of all parts and material. Inspection consisted of verifying that all instruments and controls were clearly and permanently marked, gauges were easily viewed, and controls easily operated.

The compressor configured with the P-5 Purification system was operated at no load prior to starting the actual test. No load conditions were with the vents open and the back pressure valve set at 2000 psig. An air sample was taken after one hour of operating time.

The purification unit and ancillary equipment were set up in accordance with the test plan<sup>2</sup>. A line diagram of the test configuration is depicted in Figure 3. The unit was placed in an exterior work area open to ambient temperature but protected by an awning from direct weather. A Digitech HT series, model 5820 temperature monitor and two Yellow Springs Instruments, 6700 series thermistor probes were attached to measure compressor discharge and ambient temperatures. Ambient temperatures were recorded on an hourly basis and averaged daily. The daily average temperatures were averaged for the overall test period. The overall test period average was used in determining the manufacturer's correction factor in order to calculate corrected life expectancy of the purification cartridge. A Cole Parmer humidity indicator, model 3310-20, was mounted near the compressor unit and the humidity recorded hourly. An MSA Toxgard carbon monoxide (CO) monitor with a flow range from 350 cc to 900 cc per minute, was used to analyze compressor discharge air samples before and after the purification system. One hundred percent nitrogen (N<sub>2</sub>) and 101 parts per million (ppm) CO in air were used to calibrate the monitor on a daily basis. The gases were fed through a Victor Equipment Co. 4000 psig manual regulator to a Fischer/Porter flow meter and into the monitor sensor. Carbon monoxide was introduced directly into the compressor intake through a Victor Equipment Co. 4000 psig manual regulator and Fischer/Porter flow meter. The introduction of CO was adjusted to maintain 50 ppm at the entrance of the filtration system. The compressor and purification system were operated daily to charge four 2250 cubic inch floodable volume cylinders. The four cylinders were interconnected to simulate one large air flask. When 2000 psig flask pressure was reached the vent was adjusted to allow the compressor to maintain the 2000 psig while continuously running. An arrangement of tubing provided a method to supply a gas sample from before or after the filter to the CO monitor. Shifting from the clean side to the contaminated side of the purification system was done approximately every 30 minutes to allow the monitor time to settle out between readings. Hourly CO readings are in Appendix A.

After one and a half hours of operation on the first test day the unit was secured with 2000 psig in the flasks. All vents, flowmeters, and blowdown valves were closed. The unit remained secured until 0630 the following day. The pressure drop was less than 200 psig, and was considered insignificant when temperature differentials were considered.

The NEDU test plan<sup>2</sup> contains the pass/fail criteria used during the evaluation. Appendix A is the test log and contains the recorded data.

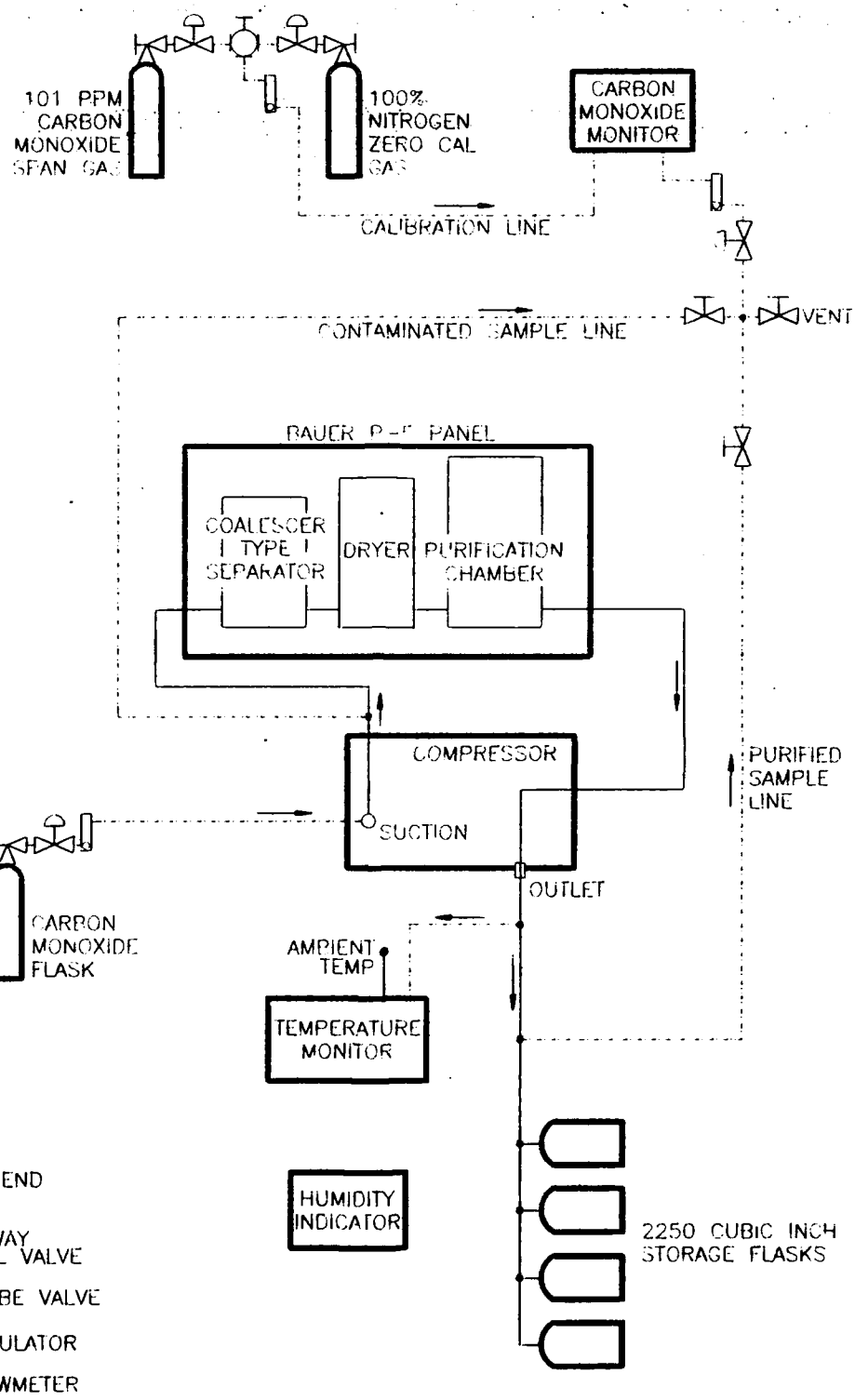


FIGURE 3. BAUER P-5 PANEL TEST CONFIGURATION

#### IV

##### ENDURANCE TEST RESULTS

The total volume of air processed was verified by charging from 1000 to 2000 psig daily. The following parameters were recorded throughout the 56 hours of operation:

- |                             |                                 |
|-----------------------------|---------------------------------|
| (1) Date                    | (9) Amperage                    |
| (2) Time                    | (11) Compressor oil level       |
| (3) Total meter hours       | (12) Compressor oil pressure    |
| (4) Total test hours        | (13) Discharge line pressure    |
| (5) Ambient Humidity        | (13) Discharge line temperature |
| (6) Ambient Temperature     | (14) CO before filter           |
| (7) Engine oil pressure     | (15) CO after filter            |
| (8) Engine head temperature |                                 |

The volume of air delivered and the time to achieve that volume was logged daily, (Appendix A). The purification system processed a total of 76473.6 cubic feet of air. Using the correction factor provided by the manufacturer, the total cubic feet of air processed equaled 146% of the expected active life of the purifier cartridge. The data collected provided a complete operational and maintenance log for this test and was the basis for computing and evaluating all the test results.

Air samples were taken from the purification system discharge at test hours 2, 15 and 56, for purity analysis at Naval Coastal Systems Center Laboratory, Code 5130. The first two samples were within established limits<sup>4</sup>. Shortly after the 56 hour sample, the indicated CO level had increased to unacceptable limits<sup>4</sup>. Results are located in Appendix B.

Maintenance consisted of two new cartridges, a No 058825 and a No. 058827, being installed prior to commencing the test. All gauges and indicator readings were checked and considered to be within normal limits. No other maintenance was required.

At 56 hours of operation into the P-5 purification system evaluation the CO monitor indicated 12 ppm from the clean side of the system. It was determined that the filter was beginning to break down and the evaluation was secured at that time.

#### V CONCLUSIONS

1. The BAUER P-5 Purification System delivers acceptable breathing air at a capacity which exceeds the manufacture's specifications.
2. The unit is sturdy and readily maintained.
3. The BAUER P-5 Purification System removes CO from contaminated air sources and delivers air of a quality that exceeds required purity standards<sup>4</sup>.
4. The BAUER P-5 Purification System is suitable for use by the U.S. Navy Diving Community.

## VI RECOMMENDATIONS

The Vendor and NAVSEA should be contacted prior to purchase, to ensure the unit meets the users needs.

If the user is concerned about CO contamination of an air supply, the incorporation of a CO analyzer in conjunction with a purification system should be considered, and is highly recommended by NEDU.

## VII REFERENCES

1. NAVSEA Task 91-002; Evaluation of commercially available filters for high pressure and low pressure breathing air.
2. NEDU Test Plan No. 91-28, Bauer P-5 Purification system Evaluation.
3. Bauer P-5 Purification System Instruction Phamplet dated Nov 1 1989  
BAUER Compressor Inc. 1328 Azalia Garden Road Norfolk Va 23502.
4. U.S. Navy Diving Manual, Vol 1, revision 2 Dec 15 1988 Para 5.3.2  
NAVSEA 0994-LP-001-9010.

TEST LOG  
BAUER P-5 PANEL MOUNTED  
PURIFICATION SYSTEM EVALUATION

A-1

TEST LOG  
BAUER P-5 PANEL MOUNTED  
PURIFICATION SYSTEM EVALUATION

**A-2**

TEST LOG  
BAUER P-5 PANEL MOUNTED  
PURIFICATION SYSTEM EVALUATION

DIESEL ENGINE					COMPRESSOR									
1991 DATE	REAL TIME	TOTAL METER HOURS	TOTAL TEST HOURS	AMBIENT HUMIDITY	AMBIENT TEMPERATURE	OIL PRESSURE	ENGINE HEAD TEMPERATURE	AMPERAGE	OIL LEVEL	OIL PRESSURE	DISCHARGE LINE PRESSURE	DISCHARGE LINE TEMPERATURE	CARBON MONOXIDE BEFORE FILTER	CARBON MONOXIDE AFTER FILTER
7-29	0700	145.7	14.5	88%	79.6°F	100	150	+5	FULL	830	100	64.4°F		
7-29	0730	146.2	15.0	87%	82.6°F	100	160	+5	FULL	850	2000	83.3°F	50 PPM	0 PPM
7-29	0800	146.7	15.5	88%	80.3°F	90	160	+5	FULL	830	2000	85.2°F	51 PPM	0 PPM
7-29	0900	147.7	16.5	84%	82.7°F	90	160	+5	FULL	830	2050	86.9°F	49 PPM	0 PPM
7-29	1000	148.7	17.5	74%	90.1°F	90	160	+5	FULL	830	2100	92.3°F	42 PPM	0 PPM
7-29	1100	149.7	18.5	75%	85.0°F	90	160	+5	FULL	820	2050	90.0°F	43 PPM	0 PPM
7-29	1200	150.7	19.5	66%	90.3°F	90	160	+5	FULL	820	2000	94.3°F	53 PPM	0 PPM
7-29	1300	151.7	20.5	78%	86.5°F	90	160	+5	FULL	810	2000	94.8°F	46 PPM	0 PPM
7-29	1400	152.7	21.5	77%	87.2°F	90	160	+5	FULL	810	2100	91.6°F	48 PPM	0 PPM
7-29	1430	153.2	22.0	78%	87.8°F	90	160	+5	FULL	810	2150	92.4°F	46 PPM	0 PPM

0700 CALIBRATED CO MONITOR  
1035 CHARGE RATE WAS TAKEN.  
AVERAGE TEMPERATURE FOR 7-29 WAS 85.21°F  
AIR PROCESSED FOR 7-29 WAS 22.4 CFM X 7.5 HRS X 60 = 10080.0 CF  
+ 17461.8 CF  
27451.8 TOTAL CF TO DATE

COMMENTS  
IT TOOK 16.0 MINUTES TO CHARGE FROM 1000 PSIG TO 2000 PSIG



TEST LOG  
BAUER P-5 PANEL MOUNTED  
PURIFICATION SYSTEM EVALUATION

A-4

TEST LOG  
BAUER P-5 PANFL MOUNTED  
PURIFICATION SYSTEM EVALUATION

**A-5**

TEST LOG  
BAUER P-5 PANEL MOUNTED  
PURIFICATION SYSTEM EVALUATION

**A-6**

TEST LOG  
BAUER P-5 PANEL MOUNTED  
PURIFICATION SYSTEM EVALUATION

A-7

TEST LOG  
BAUER P-5 PANEL MOUNTED  
PURIFICATION SYSTEM EVALUATION

[illegible]

TEST LOG  
BAUER P-5 PANEL MOUNTED  
PURIFICATION SYSTEM EVALUATION

[illegible]

# APPENDIX B

Memorandum

12 August 1991

To: Dave Sullivan, NEDU  
From: Glen Deason, Code 5130

Subject: Analysis of Air Sample from NEDU test #91-28. Bauer P-5 panel purification system evaluation. Fifty six hour sample.

1. In accordance with your request, the air sample delivered to the gas analysis lab was analyzed and found to contain:

Component	Results
Oxygen	21%
Nitrogen	78.1%
Argon	0.9%
Carbon Dioxide	382 PPM
Carbon Monoxide	24.7 PPM
Total Hydrocarbons*	3.3 PPM
Total Halogens	<0.5 PPM
Methane	1.6 PPM
Ethane	<0.1 PPM
Acetone	<0.1 PPM
Acetylene	<0.1 PPM
Methyl Ethyl Ketone	<0.1 PPM
Freon 113	<0.1 PPM
Benzene	<0.1 PPM
Toluene	<0.1 PPM
C4+	<0.4 PPM

\*Expressed as methane equivalents

2. The above sample showed appreciable contamination; all components were not within the acceptable range of the USN Diver's Air Purity Standards.

  
Glen Deason  
Chemist

Memorandum

25 July 1991

To: Dave Sullivan, NEDU  
From: G. Deason, Code 5130

Subject: Analysis of air sample from Bauer P-5 purification system evaluation. Two hour sample.

1. In accordance with your request, the air sample delivered to the gas analysis lab was analyzed and found to contain:

Component	Sample
Oxygen	21%
Nitrogen	78.1%
Argon	0.9%
Carbon Dioxide	103 PPM
Carbon Monoxide	<0.5 PPM
Total Hydrocarbons*	1.6 PPM
Total Halogens**	<0.5 PPM
Methane	1.6 PPM
Acetylene	<0.1 PPM
Acetone	<0.1 PPM
Freon 113	<0.1 PPM
Methyl Ethyl Ketone	<0.1 PPM
Ethylene	<0.1 PPM
Toluene	<0.1 PPM
Benzene	<0.1 PPM
Formaldehyde	<0.1 PPM
C4+	<0.1 PPM

\*Expressed as methane equivalents.

\*\*Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all components were within the acceptable range of the U.S. Navy Diver's Air Purity Standards.

  
Glen Deason  
Chemist



Memorandum

30 July 1991

To: Dave Sullivan, NEDU

From: G. Deason, Code 5130

Subject: Analysis of air sample from NEDU test #91-28. Bauer P-5 purification system evaluation. Fifteen hour sample.


1. In accordance with your request, the air sample delivered to the gas analysis lab was analyzed and found to contain:

Component	Sample
Oxygen	21%
Nitrogen	78.1%
Argon	0.9%
Carbon Dioxide	440 PPM
Carbon Monoxide	<0.5 PPM
Total Hydrocarbons*	2.5 PPM
Total Halogens**	<0.5 PPM
Methane	2.5 PPM
Acetylene	<0.1 PPM
Acetone	<0.1 PPM
Freon 113	<0.1 PPM
Methyl Ethyl Ketone	<0.1 PPM
Ethylene	<0.1 PPM
Toluene	<0.1 PPM
Benzene	<0.1 PPM
Formaldehyde	<0.1 PPM
C4+	<0.1 PPM

\*Expressed as methane equivalents.

\*\*Expressed as methyl chloride equivalents.

2. The above sample showed no appreciable contamination; all components were within the acceptable range of the U.S. Navy Diver's Air Purity Standards.

  
Glen Deason  
Chemist